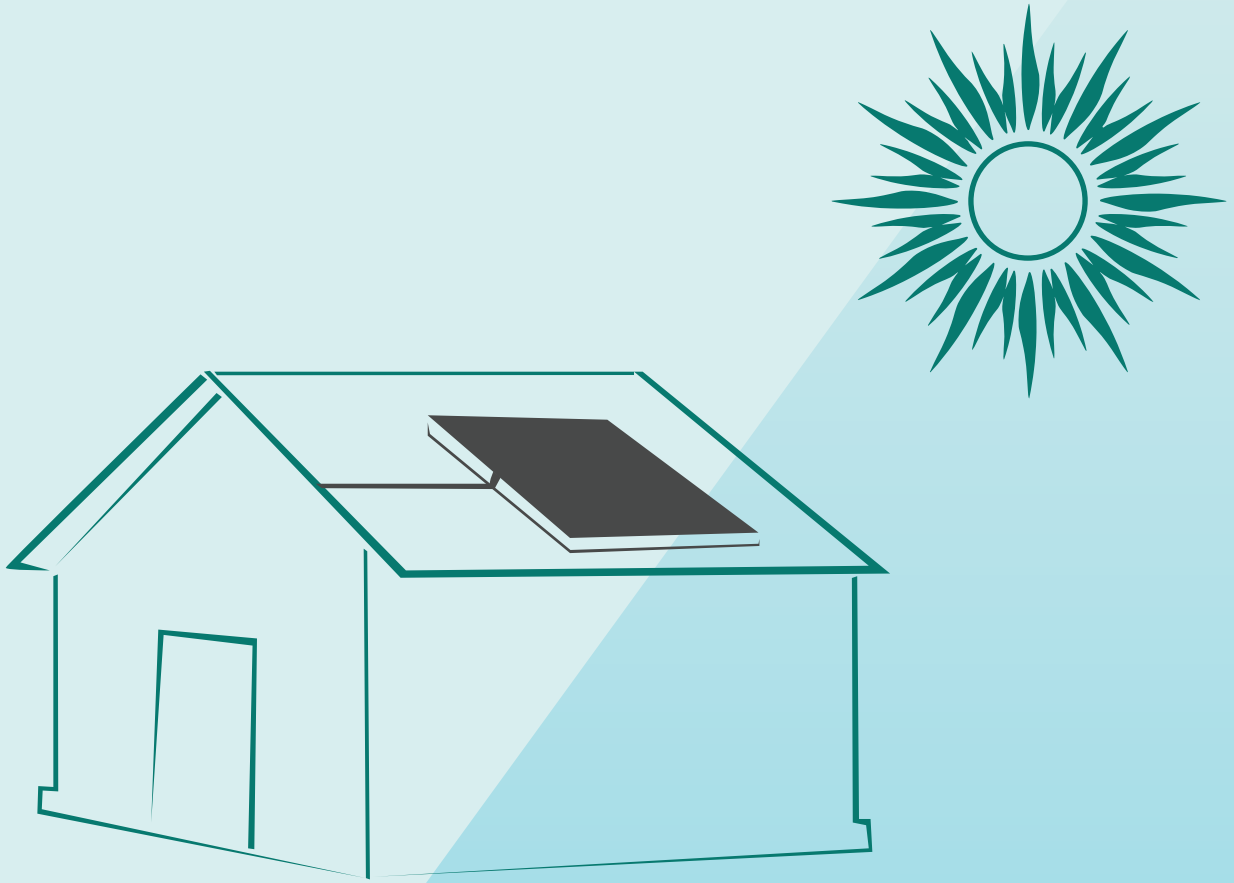


BENEFITS OF LIGHTING – A COST BENEFIT ANALYSIS ON DISTRIBUTED SOLAR HOME SYSTEMS

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Benefits and costs of deploying
distributed solar systems in Bangladesh



SMARTER SOLUTIONS FOR
BANGLADESH



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Bangladesh Priorities

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This work has been produced as a part of the Bangladesh Priorities project, a collaboration between Copenhagen Consensus Center and BRAC Research and Evaluation Department.

The Bangladesh Priorities project was made possible by a generous grant from the C&A Foundation.

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Introduction

Use of solar home systems (SHS) is on the rise. There are millions of households across many countries in the world where SHS has been promoted as a strategy to 'light' off-grid rural houses. In many countries, including Bangladesh, this is part of a major public policy focus of the government because it has effectively 'lighted' 3 million houses in remote locations who are unlikely to have electricity from grid connections. In countries like India, solar has been promoted using public subsidy for rural people but in Bangladesh, there is only a small subsidy of \$25 provided by the World Bank, GiZ, and other donors, equivalent to about 3.5% of the nominal lifetime cost over 20 years. Instead, it is being financed using micro-credit at a reduced rate of interest (6% per annum). It has been a major success because it has been able to light millions of households at zero investment from the Government of Bangladesh.

A study on SHS by the World Bank noted that "Bangladesh's experience with SHS has been a phenomenal success, as noted in the energy development literature. Because of its innovative program design, including a price-support scheme to reduce the cost of SHS purchase and maintenance, Bangladesh's success story appears to be an option for accelerating SHS adoption in poor countries". (Shahidur, Hussain, Sadeque, Asaduzzaman, Yunus, & Haque, 2014). Yet, there are several unanswered questions. It is true that millions of rural poor households who cannot afford a 60\$ bed in their homes but purchased a SHS to light their homes at a cost of nearly 280\$¹. The key to such success was micro-credit facilities which gave them this access at ease. For a rational decision maker, the net benefit must have been positive. However, it is may not be so obvious.

Similarly, while millions of Bangladeshi poor households are borrowing money to light their house, million others living in cities are purchasing diesel-powered generators also to light their houses during regular power cuts. Moreover, a government plan of mandatory SHS for new homeowners in cities has also failed to produce the desired results since most of the solar systems practically remained in-operative. Homeowners decided to depend upon diesel power to light their houses during power cuts. Could it be a failure in their institution to run solar powered system or was it also a rational decision for them to opt out of solar?

Finally, the World Bank, GiZ, and other donor agencies in Bangladesh have been financing the SHS in off-grid areas. So far, they have not done so in grid areas. Their decision is primarily guided by consideration of poverty of the rural households living in remote areas. Is this a rational decision? These are the questions that are examined in this paper.

Solar Home Systems

Rapid economic growth of Bangladesh that began since the early 90s led to sharp rise in demand for electricity in Bangladesh. The trend as it continued will lead to creation of production capacity of nearly 10,000 MW of power by 2021 (Mujeri, Chowdhury, & Shahana, 2014). This has led to nearly a billion dollar subsidy by the government for generation and distribution of power in mostly urban locations. Most of the rural areas are still out of reach of grid connections. A decentralized energy-generation mechanism based on solar photovoltaic (PV) system, thus, provided an alternative to light these houses. (Shahidur, Hussain, Sadeque, Asaduzzaman, Yunus, & Haque, 2014)

In many developing countries, there was a second challenge – how to finance this investment? Fortunately, in Bangladesh, the micro finance institutions provided an opportunity. Thus, with a financing scheme developed by the Infrastructure Development Company Limited (IDCOL – a public-private financing company), partner micro finance NGOs began selling solar home systems in remote

¹ The upfront cost of the SHS is US\$280, but ongoing costs, notably the replacement of the battery every five years adds another US\$853 to the lifetime cost of the solar panel.

locations. The program is also partially funded by GiZ, the World Bank and several others in order to promote 'light' to rural houses. The system consists of three major components – a) solar PV panels – which has an average life of 20 years; b) a battery – which has an average life of 5 years, and c) a charge controller – which has life equivalent to a PV panel. A typical SHS unit sold through this scheme had a price of 22,000 Taka (or 280\$) (after a deduction of 25\$ received as grant from the World Bank and other donors). Of total price for a SHS, 15% is paid in cash by the household as down payment, while the rest 85% is paid by the micro-credit institutions through a credit scheme. The collective efforts of the government, donor agencies and NGOs led to a surge in off-grid solar connections in Bangladesh. By 2015, there are 3 million households connected to solar home systems.

Promoting SHS through micro credit scheme is not new in the world. India, Costa Rica, Kenya, El Salvador, Guatemala, Panama, and many other countries also used micro-finance to light remote rural areas.

Benefits of SHS

Benefits to adopting household

Rural households visualize an ‘immense’ benefit to it and so they borrow money to install it at their roof-tops. A World Bank study reveals that typical benefits to households using SHS in remote rural areas include – a) aesthetic benefit of bright lights replacing the kerosene lamps (mostly of one wick), b) better social status with access to amenities like TV, mobile phones, etc.; c) improved performance of kids in schools due to longer hours of study, d) reduced exposure to indoor air pollution (from kerosene lamps), e) increased night time activities due to better light; and f) increased economic activities or income at the rural households (Shahidur, Hussain, Sadeque, Asaduzzaman, Yunus, & Haque, 2014).

The cost to a household in this scheme is of three types: a) amount paid as down payment, b) amount paid to micro-credit institutions as EMI, and c) replacement costs of batteries at every 5 years, where again there are provisions of down payment of 15% and the rest as credit. For the global community, the 25\$ subsidy is the only cost of the project for every unit sold.²

There are two aspects of valuing these benefits – a) measurement of changes and b) monetizing the benefits. The World Bank study provided an initial entry to this analysis. The study by Shahidur *et al.* (2014) used a randomized survey on both SHS users and non-users and used the PSM method to establish changes in behaviour between users and non-users of SHS. It showed that typical households using SHS benefited from this switch in terms of a) study time for boys and girls at home during evening hours, b) reduced sickness at home from respiratory tract and other illness, c) reduced expenditure on kerosene, d) better standard of living with more durable assets in the house, e) higher income for SHS households, f) reduced fertility of women and also g) greater voices of women in the SHS households (Shahidur, Hussain, Sadeque, Asaduzzaman, Yunus, & Haque, 2014). In addition to these, the report also provided indirect estimates of carbon benefits since solar home systems replaces kerosene – the fossil fuel, which is responsible for emitting black carbon into the atmosphere.

Valuing the benefits from such diverse ranges of benefits is a challenge. First, there is a need to define the right product. Clearly, families do gain due to adoption of solar homes for which they make such a hefty³ investment. The list of benefits revealed in the World Bank study also provides a convincing reason for installing solar home systems in their homes, and found a benefit-cost ratio of 6 for SHS in non-grid areas of Bangladesh.

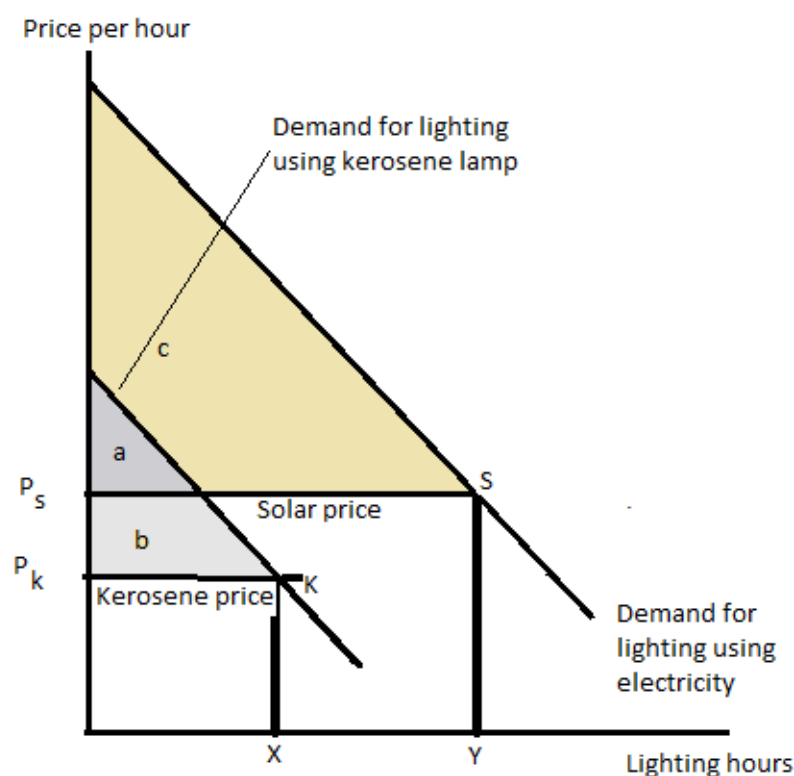
Figure 1 below shows the benefits of solar home system for a rural household without a grid electricity connection. In the Figure 1, we first assume that there is an existing demand for lighting using kerosene lamp at the household level at a price (P_k). At this price, households consume ‘X’ hours of light per day, thus enjoys ‘a+b’ amount of consumer’s surplus against its cost of lighting using kerosene. As we introduce solar power at the household level, the demand for lighting using electricity ‘shifts’ because of the benefits listed previously. It means, as other factors have changed due to improved quality of lighting (from electricity), households begin demanding higher amount of light hours (Y) at a price P_s . So with the shift in the demand curve the net welfare from the switch is equal to ‘(a+c-b)’. If the a+c-b is positive, household is likely to adapt the change and if it is negative it is unlikely to switch from kerosene to solar. At the same time, if price for an hour of electric light using solar is less than that of kerosene lamps, the household will definitely see a positive surplus due to shift to solar.

² This provision is no longer valid for majority of the POs under IDCOL. It was originally designed to subsidize the NGOs to provide this loan and to ease financial burden on the household.

³ For an average household who install such units, monthly per capita income 2303 taka or 29\$ (Shahidur, Hussain, Sadeque, Asaduzzaman, Yunus, & Haque, 2014) p – 49 (for non-SHS household).

Clearly, an increase in welfare at the household level is not guaranteed through using solar lighting and so we see that not all households make the switch even when the financing problem is sorted.

Figure 1: Welfare effects from adoption of solar home system



Benefits to global communities

Apart from the benefit accrued to the household from switching to solar (from kerosene lamps), there is also a global benefit attached to it because solar power is a part of the low carbon growth strategy for a country. In Bangladesh, when millions of households are waiting to switch to electricity based lighting, a switch to solar may lead to lowering of CO₂ emission from Bangladesh. This is because kerosene burning emits CO₂ into the atmosphere and a switch from kerosene to solar reduces CO₂ emission and hence benefits the global community.

A Caveat

Up until this moment, this analysis follows what has been described in standard literature of cost benefit analysis. Benefit measurement is now possible as soon as we have estimates of the shift in demand curve (observed measurement of Y) at a price of solar light (P_s). However, there are two issues to ponder about for a clear conclusion on attribution of these benefits to solar. Imagine that we have been able to provide electricity to the same household using another alternative fuel. The question is: Will the demand curve for electricity using any alternative fuel be different from that of using solar power? The answer is: no. Therefore, the demand for electricity, here, is *de facto* demand for electric lighting from any other sources as long as the quality of lighting remains same. Under this situation, the analysis presented in Figure 1 only shows benefit from lighting using electricity against kerosene lamps. This is because all of the listed benefits from solar lights will still be valid with electricity from any alternative sources of fuel.

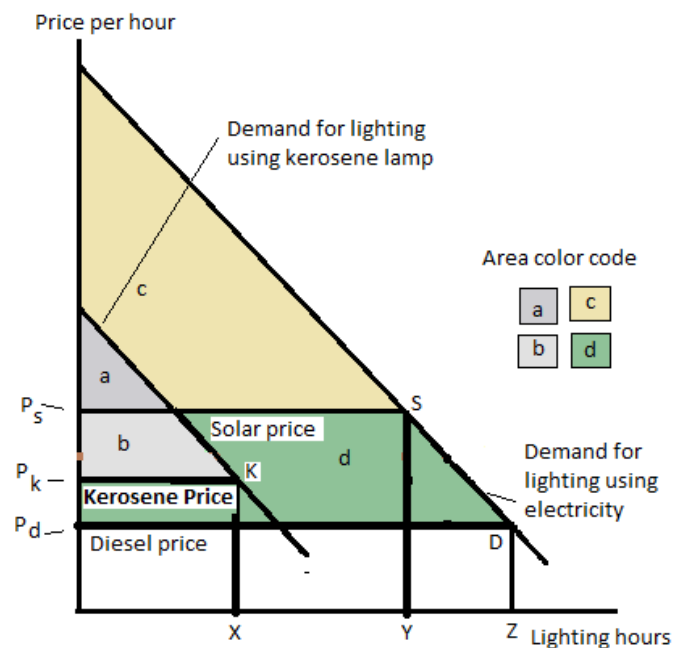
In this situation, the critical issue is to know whether the solution using solar is cost effective for the household relative to any other sources of fuel. For an off-grid household, the alternative could be

a) diesel-powered electricity, or b) bio-gas powered light. In this analysis, we consider diesel-powered electricity as an alternative, particularly small-scale sharing of diesel generators among a cluster of households.

Analysis using alternative fuel

Like solar, we have already seen a similar surge in diesel-powered generators among urban households who were regularly going through power cuts on a daily basis. Clearly, these households (who are rich and are living in urban areas) found it 'cheaper' to light their houses with diesel than with solar. Under this, situation an alternative analysis is presented in Figure 2. In Figure 2, it shows that if the price of electricity using diesel-powered generator is P_d (here $P_s > P_k > P_d$),⁴ and if the quality of electricity does not differ (obviously not), then household would have increased its consumptions of electricity to Z (instead of Y) and there will be an additional gain from the investment of an area equal to the area colored as 'd'. Clearly, if the alternative fuel is cheaper than solar, households will find no incentive to switch to solar if they have similar access to finance. Alternatively, if households are already using diesel, they will also not find any reason to switch to solar. Therefore, under this situation, solar remains attractive to poor households if and only if the ground conditions of finance are different and micro-credit facility is only available for purchase of solar home system. This explains why IDCOL's effort has been such a success in Bangladesh. It also explains why richer households, who do not need finance support to install a generator, are not interested in solar. As we show below, the condition that allows the price of diesel to be cheaper than solar involves the sharing of generators among a cluster of (five) households.

Figure 2: Analysis of Benefits from Electricity using SHS vs Diesel Generators



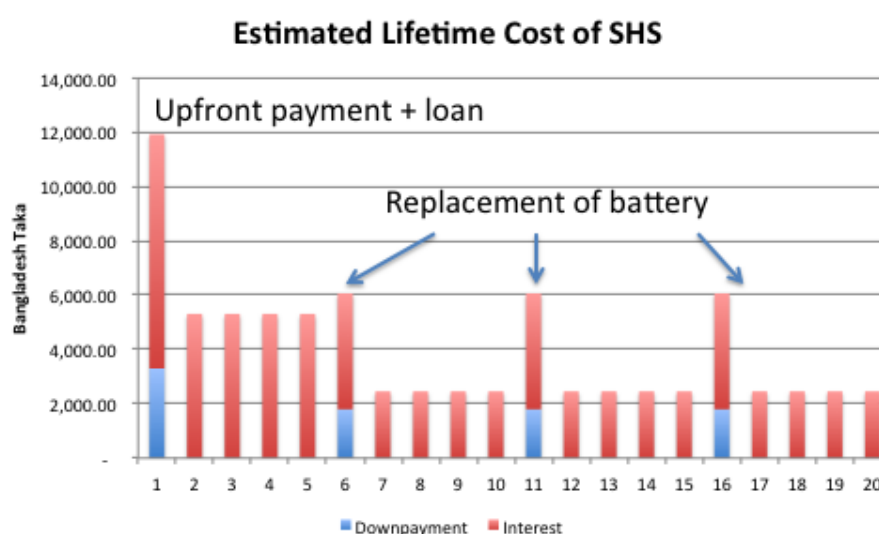
⁴ Kerosene price/hour = (monthly liter per household x kerosene price) / (30 days x 2 hours) = 3.22 taka / hour; Solar price/hour = (current price of SHS + 3 x Battery price) / (20 years x 365 days x 2 hours) = 4.59 taka / hour; Diesel price / hour = (2 x generators price [shared proportionately among participating households]) / (20 years x 365 days x 2 hours) + liter of diesel / hour x price of diesel = 1.84 taka / hour; During this calculation we fixed hours of lighting to 2 hours across different sources of light to find an average cost of lighting. In reality, however, the average cost per hour is likely to go down when households increase their hours of operation while using solar and diesel powered lighting because of fixed costs.

For the global community, however, the critical issue is to see whether there is a net benefit from financing households to switch to solar as it reduces CO₂ emissions. In this case, there are two scenarios to test. Is there a net benefit for global community to financing households who are currently using kerosene lamps? Or is it more beneficial for the global community to finance households who are currently using diesel-powered generators? Which one is more beneficial from carbon emission reduction point of view?

Analysis

PV solar panels have 20 years lifetime when they are installed (according to IDCOL documents). However, each SHS unit contains lead-acid battery, which usually has a life time of 5 years only. IDCOL's financing scheme allows households to borrow 85% of the cost of the unit as a loan at 6% rate of interest for 6 years using EMI payment scheme. According to the market information in Bangladesh cost of battery is nearly 60-70 per cent of the initial cost of SHS. Batteries are mostly replaced in every 5 years⁵ and we assume a similar credit scheme for battery replacement. We also assume that batteries are returned to the NGOs in order to ensure their recycling. Hence, in this analysis external cost of dumping batteries as waste is not considered. The estimated lifetime cost of the SHS is depicted in Figure 3, totalling approximately 67,000 taka in nominal terms over 20 years. Given a total usage of 4 hours per day (and rising by 2% each year⁶) the cost of an hour of solar power is 4.59 taka over 20 years.

Figure 3: Lifetime cost of Solar Home System



Notes: Estimation is based on 22,000 taka upfront cost, paid with a 15% down-payment, with the rest financed by a 6%p.a. five year loan. Every five years a battery costing 12,000 taka has to be replaced using a loan with the same conditions.

In case of a diesel-powered generator, the upfront cost is a 15,000 taka generator. There is no credit scheme available for purchase of generator and there is no global subsidy for them. On-going costs such as maintenance, the price of fuel and the replacement of the generator, put the total nominal cost of using diesel at approximately 134,106 taka over 20 years.⁷ Since the initial investment cost is

⁵ IDCOL requires that partner NGOs provide a warranty on battery for 5 years.

⁶ To capture the income effect.

⁷ This assumes a cost of fuel of 68 taka per liter and O&M costs of 20% of the upfront cost p.a. We also assume the generator has to be replaced every 10 years.

beyond the ability of a poor household, they cannot afford to purchase a diesel generator alone without credit facility. This is, particularly true for those living in areas unconnected to the grid. It is also more expensive than a SHS, and the case where a single household uses a diesel generator for electrification does not pass a cost-benefit test at their current rate of consumption.⁸

However, while most of the SHS units are of 40Wp (Watt Peak), the generator is of 200 KVA. Therefore, we assumed that electricity from a generator is shared among five neighbouring households and each one receives the same power of electricity so that the lighting quality is same as in the case of SHS.

Under these conditions, and assuming that participating households share resources proportionately both for purchase and for operation of the generator, the total cost for one hour of electricity is 1.84 taka per hour for the same quality of electricity as the SHS. At this lower price given the elasticity of demand for electricity⁹, households consume 6 hours of electricity per day compared to 4 hours per day for SHS based on the same demand curve for electricity (see Figure 2).

Cost Benefit Analysis

Based on the above consideration, we present a cost benefit analysis for three cases. In case I, households switch from kerosene lamps to solar home system using the micro-credit facilities (with 15% down payment). For this analysis, we assume a credit facility at 6% rate of interest but a 5 years repayment period (with EMI) so that in the 6th year they have paid off the loan and are now eligible to take a credit to replace the battery. As before, households will receive a new loan with 15% down payment at the same interest rate and this goes on for every five-year period till the end of the life time of the panels (i.e. 20 years).

In case II, households switch from kerosene lamps to diesel-powered generator. As discussed, we assume that electricity from a generator is shared among five neighbouring households and each one receives the same power of electricity so that the lighting quality is same as in the case of SHS. For purchase of diesel-powered generator there are no credit facilities, and no global subsidy. Therefore, both fixed and variable costs are shared by all households sharing electricity from the generator.

In case III, we analysed a scenario where the existing diesel-powered generators are considering an investment for a similar SHS unit. We further assume that if SHS is not available a good number of households who are now using SHS would have purchased diesel-powered generators to light their houses (shown in Figure 4) – the real counterfactual scenario without SHS.

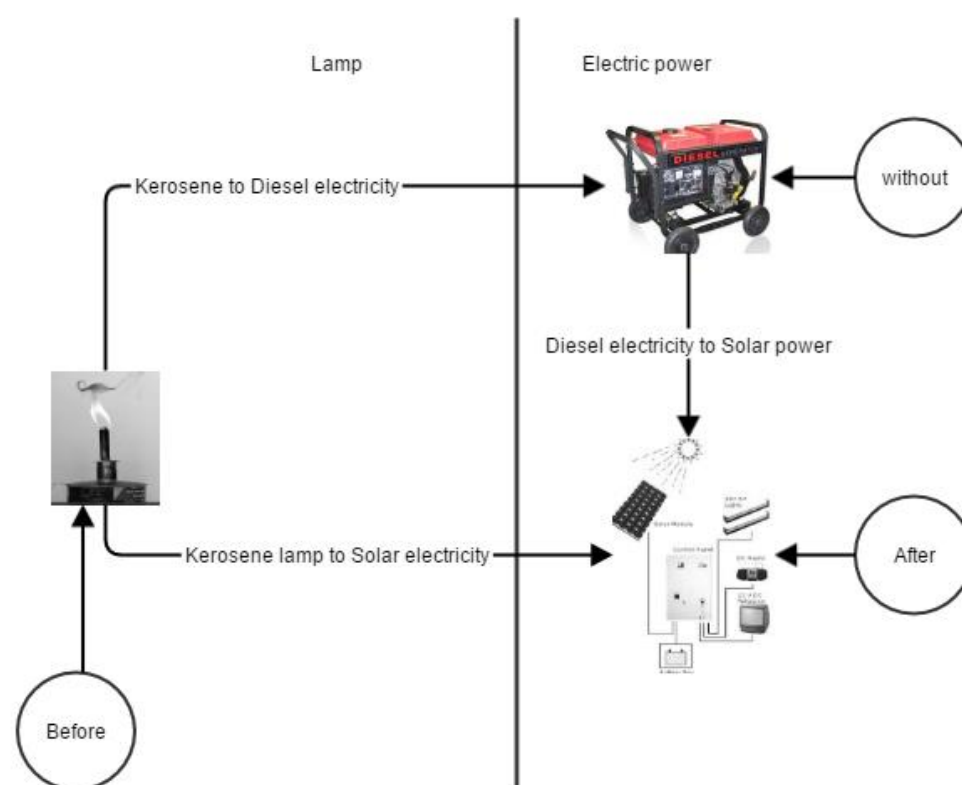
In each scenario, we consider the counterfactual costs and benefits. This means for cases I and II, the counterfactual is lighting from kerosene lamps, while for case III it is diesel generation. The nominal lifetime costs of kerosene are approximately 74,000 taka over 20 years, all is the cost of fuel (the fixed cost for a one wick kerosene lamp is near zero). The benefits are the counterfactual change in consumer surplus given by Figures 1 and 2.

Additionally, in this analysis, price of carbon per ton of CO₂ is assumed to be 22.9 US \$ for a 3% social rate of discount and it is 5.18 US\$ at 5% rate of discount (Tol, 2011)). For the 10% rate of discount the social cost of carbon is \$0. Analysis presented here uses discount rates of 3%, 5% and 10%.

⁸ At the 5% level, the BCR for a single household using diesel is 0.68.

⁹ In the World Bank study the price elasticity was estimated to be -1.06 (Shahidur, Hussain, Sadeque, Asaduzzaman, Yunus, & Haque, 2014).

Figure 4: Scenarios for Cost Benefit Analysis



Results

Results of the cost benefit analysis is shown in Table 1 below. Case I represents a situation where households are currently using kerosene lamps for lighting their houses and are replacing it with an investment in SHS. Case II represents a situation where households are weighing their alternatives for lighting their houses using electricity from diesel-powered generators and Case III represents a possible situation where one household sharing a diesel powered generator could possibly switch to SHS.

Table 1: NPV, BCR and CO₂ emissions for lighting using SHS vs Diesel Generator

| | Case I | | | Case II | | | Case III | | |
|------------|-------------------------|-------|-------------------|------------------|-------|-------------------|--------------------|---------|-------------------|
| | K2SHS ¹ | | | K2D ² | | | D2SHS ³ | | |
| Changes to | NPV | BCR | CO ₂ * | NPV | BCR | CO ₂ * | NPV | BCR | CO ₂ * |
| | at 3% rate of discount | | | | | | | | |
| Household | 25,226.28 | 2.135 | | 127,009.04 | 25.74 | | (82,872.80) | 46.57 | |
| Global | (1,876.74) | 0.043 | 0.05 | (17,005.01) | | (9.46) | 15,128.27 | 8.71 | 9.51 |
| | at 5% rate of discount | | | | | | | | |
| Household | 17,537.06 | 1.826 | | 104,594.76 | 24.91 | | (71,354.18) | (61.13) | |
| Global | (1,942.71) | 0.010 | 0.05 | (3,846.55) | | (9.46) | 1,903.83 | 1.97 | 9.51 |
| | at 10% rate of discount | | | | | | | | |
| Household | 6,082.82 | 1.322 | | 68,641.97 | 22.51 | | (52,128.23) | (8.85) | |
| Global | (1,962.00) | - | 0.05 | - | | (9.46) | (1,962.00) | - | 9.51 |

NOTE: 1 K2SHS – Kerosene lamp to solar home system, 2 K2D - Kerosene lamp to small scale sharing of diesel, 3 D2SHS – Small scale sharing of diesel to solar. * CO₂ emission per household for 20 years in Ton

Table 1 shows that households find a positive net benefits if the choice is given to switch to solar from kerosene at 3, 5 and 10 per cent rate of discount. However, our results show that the IRR for household is 15.7% for case I. This means that if individual households have a discount rate above 15.7%, they will not purchase SHS even with micro-credit facilities. Our analysis at 3% rate of discount further shows that for each SHS unit, only 0.05 ton of CO₂ is saved in 20 years. Its market price is only 1.09 US\$ (Table 2). Using 25\$ subsidy per SHS unit, this means a benefit cost ratio of only 0.043 (Table 1).

Table 1 also shows that in Case II, households receive a BCR of 25.74 for 3 per cent social rate of discount. It further shows that such a move (switching to diesel instead of solar) will increase net CO₂ emission by nearly 9.46 ton for each SHS unit (Table 1) – i.e. a net loss to global community. Using a 3% discount rate for global community this implies a net loss of 216.68 US\$ (Table 2) per unit of SHS in 20 years. Using a ‘real’ counterfactual scenario where households would have switched to diesel-powered generator in absence of the current financing mechanism through IDCOL, the potential global benefit from financing a SHS is \$217.77 US\$ (as in case III) in terms of avoided CO₂ costs (Table 2). Currently a global subsidy of 25\$ means that the benefit cost ratio for this project (encouraging a move away from diesel and to solar) to the global community is 8.71. At 5% rate of discount is BCR is 1.97 (Table 2).

Table 2: CO₂ Benefits from financing electricity using solar

| | | Benefits in US \$ from CO ₂ emissions | |
|----------|-------------------------|--|-----------------|
| | CO ₂ in Tons | 3% [BCR] | 5% [BCR] |
| Case I | 0.05 | \$ 1.09 [0.044] | \$ 0.25 [0.01] |
| Case II | (9.46) | \$ (216.68) | \$ (49.01) |
| Case III | 9.51 | \$ 217.77 [8.71] | \$ 49.26 [1.97] |

Source: Author’s calculation. Note: Numbers within parenthesis are negative numbers and it mean a net loss, positive numbers mean a net gain. Figures within square brackets are benefit-cost ratio for global community.

Discussion

The results above provide significant food for thought when considering the options available to government for providing electricity in off-grid areas. One obvious question that arises from the very large benefit-cost ratio for small scale sharing of diesel electricity: if the investment is so valuable why is adoption not happening naturally in rural areas? Put it differently, why are there 3m households connected to SHS rather than 3m households sharing diesel generators on a small scale if the latter is clearly superior in terms of household costs and benefits?

The reason is three-fold. As mentioned previously, preferential financing and a small subsidy are available for SHS, while the same financing mechanism is not available for diesel generators. To finance the condition under Case II would involve five times as many parties collectively borrowing less money up front than under the SHS scheme, making it economically unattractive for microfinance institutions to engage in such an arrangement. This clearly places an implementation bias towards SHS.

Secondly, and more importantly, private sharing or distribution of electricity is illegal in Bangladesh for neighbouring households, mainly on safety grounds. This places a legal barrier against the type

of small-scale sharing suggested in this analysis and could foreseeably deter many households from engaging in this activity. However, the same sharing of diesel-generated power is perfectly legal for households living in the apartment block in urban centres. This distinction made between horizontally adjacent households versus vertically adjacent households seems unreasonable. Our suggestion is that small-scale sharing of diesel generators among five households or less should be made legal to allow rural Bangladeshis to capture the significant benefits of electrification.

Finally, and related to the other two reasons, *individual* purchase and self-financing of diesel generators is not feasible, nor is it cost-beneficial for rural households. A certain level of coordination is required to implement the sharing, and this might curtail natural occurrence of the intervention.

Another question that may be raised from this analysis: why is the benefit-cost ratio for SHS in this study around 2, different to the World Bank analysis, which found a benefit-cost ratio of 6? Though there are several differences, the primary one is the treatment of benefits. The benefits in this study are measured as the change in consumer surplus when moving from one source of lighting to another (see Figures 1 and 2). The consumer surplus, being a function of the demand, implicitly incorporates all the benefits to the purchaser when buying the SHS (or diesel generator)¹⁰, and is thus used as the basis for benefits in this study.

In the World Bank study, the main source of benefit is a 1500 taka monthly boost to income (p55-56). However, the World Bank study fails to note a feature of more work: Increased income is earned by sacrificing time, including leisure. Indeed on p53 of the report, the study notes that: “SHS adoption decreases women’s leisure time”, which is probably a result of being able to devote more time to income generating activities. This is a ‘cost’ of income, and cannot be ignored.

The 1500 taka monthly income boost *adjusted for the lost leisure time*, is incorporated as part of the consumer surplus used in this study and arguably is a more accurate reflection of the benefits from SHS.

Conclusion

The analysis above clearly shows that a) rural households with a discount rate of 15.7% or below will find it worth to switch to solar if they have access to credit facilities; b) benefit cost ratio is much higher for houses to move to diesel-powered generator so, in absence of incentives, they would probably move to light their house with diesel-powered generators, if they had similar access to micro-credit facilities. This, however, will lead to a significant rise in CO₂ emission and so global communities will find it more beneficial to extend help to allow households to switch from kerosene to solar, thereby they bypass switching to diesel for electricity; c) a mechanism that would pursue diesel-powered generator owners to switch to solar mode will have a significant positive global benefits. Thus owners will not find any real economic benefit from switching to solar from diesel. This should be pursued as a global strategy in order to promote a low-carbon growth economy in Bangladesh; d) net benefits to global community from financing a low carbon growth (switching out of diesel-powered generators) is as high as 1.97 times (for 5% rate of discount) or 8.71 times (at 3% rate of discount) per dollar spent on promoting SHS in Bangladesh. Therefore, solar home system should be promoted in urban areas too. Since NPV is still negative, an alternative strategy to incentivise homeowners to sell solar-powered electricity to grid lines (thus, ensuring a greater degree of monitoring) while, at the same time, a penalty for not producing a minimum proportion of their electricity consumption using solar will help promote low carbon strategy of economic growth.

¹⁰ The demand function for lighting is a revealed demand function and hence measures the maximum willingness to pay for all the accrued benefits to the household from lighting (direct and indirect).

This incentive and the penalty system together will also reduce public investment requirements for production of electricity during daytime peak hours.

Table 3a: Summary of Benefits, Costs, NPV, BCR for Solar Home System – Household and Global Benefits

| | | Social rate of discount | | | |
|--|-------------|-------------------------|-------------|----------------------|------------|
| | | 3% | | 5% | |
| | Description | Household | Global | Household | Global |
| Case I – Kerosene to Solar Home System | | | | | |
| Benefits | PV | 47,450.82 | \$ 1.09 | 38,763.90 | \$ 0.25 |
| Costs | PV | 22,224.55 | \$ 25.00 | 21,226.83 | \$ 25.00 |
| Net Benefits | NPV | 25,226.28 | (23.91) | 17,537.06 | (24.75) |
| BCR | B/C | 2.14 | 0.043 | 1.83 | 0.010 |
| Case II – Kerosene to Small Scale Sharing of Diesel | | | | | |
| Benefits | PV | 132,142.29 | \$ (216.68) | 108,969.57 | \$ (49.01) |
| Costs | PV | 5,133.25 | | 4,374.82 | |
| Net Benefits | NPV | 127,009.04 | \$ (216.68) | 104,594.76 | \$ (49.01) |
| BCR | B/C | 25.74 | | 24.91 | |
| Case III – Small Scale Sharing of Diesel to Solar Home System | | | | | |
| Benefits | PV | (84,691.46) | \$ 217.77 | (70,205.68) | \$ 49.26 |
| Costs | PV | (1,818.66) | \$ 25.00 | 1,148.50 | \$ 25.00 |
| Net Benefits | NPV | (82,872.80) | 192.77 | (71,354.18) | 24.26 |
| BCR | B/C | No investment in SHS | 8.71 | No investment in SHS | 1.97 |
| Price per hour of lighting | | | | | |
| with Kerosene | BDT / hr | 3.22 | | 3.22 | |
| with Diesel | BDT / hr | 1.84 | | 1.84 | |
| with Solar | BDT / hr | 4.59 | | 4.59 | |
| CO2 price | \$ / Ton | \$ 22.90 | | \$ 5.18 | |

Table 3b: Summary of Benefits, Costs, NPV, BCR for Solar Home System – Total Social Benefits

| | 3% | 5% | 10% |
|--------------|---|---------------|---------------|
| | Total Social Benefits | | |
| | <i>Case I – Kerosene to Solar Home System</i> | | |
| Benefits | 47,535.6 | 38,783.1 | 24,995.4 |
| Costs | 24,174.5 | 23,176.8 | 18,912.5 |
| Net Benefits | 23,361.0 | 15,606.2 | 6,082.8 |
| BCR | 1.97 | 1.67 | 1.32 |
| | <i>Case II – Kerosene to Small Scale Sharing of Diesel</i> | | |
| Benefits | 115,241.28 | 105,146.55 | 71,833.68 |
| Costs | 5,133.25 | 4,374.82 | 3,191.71 |
| Net Benefits | 110,108.03 | 100,771.73 | 68,641.97 |
| BCR | 22.45 | 24.03 | 22.51 |
| | <i>Case III – Small Scale Sharing of Diesel to Solar Home System</i> | | |
| Benefits | (67,705.72) | (66,363.49) | (46,838.31) |
| Costs | 107,551.83 | 3,098.50 | 5,289.92 |
| Net Benefits | (175,257.54) | (69,461.99) | (52,128.23) |
| BCR | No investment | No investment | No investment |

Note: If NPV < 0 then household will have no incentive to invest in it.

Acknowledgment – the author gratefully acknowledges the contributions made by Dr. Brad Wong during finalization and interpretation of the results of this study.

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